

*DRO CONTINGENCIES: AN ANALYSIS OF  
VARIABLE-MOMENTARY SCHEDULES*

JANA S. LINDBERG, BRIAN A. IWATA,  
SUNGWOO KAHNG, AND ISER G. DELEON

THE UNIVERSITY OF FLORIDA

We conducted several comparative analyses to determine the relative effectiveness of variable-momentary differential-reinforcement-of-other-behavior (VM DRO) schedules. Three individuals who had been diagnosed with mental retardation participated. Results of functional analyses indicated that their self-injurious behavior (SIB) was maintained by social-positive reinforcement. Two individuals participated in a two-stage comparative analysis within multielement and multiple baseline designs. Fixed-interval (FI) and variable-interval (VI) DRO were compared in the first stage; VI DRO and VM DRO were compared in the second. All three schedules effectively reduced the participants' SIB. Treatment for the 3rd individual was conducted in a reversal design to examine the effects of VM DRO when it was implemented in isolation, and results indicated that the procedure was effective in reducing SIB. These findings suggest that VM DRO schedules may represent attractive alternatives to traditional FI schedules because momentary schedules do not require continuous monitoring and may result in higher rates of reinforcement.

DESCRIPTORS: differential reinforcement of other behavior, functional analysis, self-injurious behavior

Differential-reinforcement-of-other-behavior (DRO) contingencies were first studied extensively by Reynolds (1961), who observed that pigeons' key pecking decreased to very low rates when reinforcement was delivered following periods during which responding was absent. Subsequently, Uhl and Garcia (1969) observed that the durability of response suppression was greater under a DRO contingency than under extinction. These behavior-reducing properties of DRO have been demonstrated many times in both basic and applied research (see Poling & Ryan, 1982; Vollmer & Iwata, 1992, for reviews), and DRO has emerged as one of the

most commonly used treatments for a wide range of behavior problems (Lennox, Miltenberger, Spengler, & Erfanian, 1988).

Because the basic DRO contingency merely specifies that reinforcement is delivered following interresponse times (IRTs) that are equal to or greater than  $t$  (the interval length), a number of procedural variations are possible and have been reported in the literature. In clinical application, DRO is often used to reduce the frequency of problem behavior that is maintained by some preexisting source of reinforcement. Therefore, one consideration in using DRO is the relationship between the behavior's maintaining reinforcer and the reinforcer delivered under the DRO contingency. In some cases, arbitrary reinforcers (those not responsible for behavioral maintenance) have been delivered because maintaining reinforcers were unknown (e.g., Harris & Wolchik, 1979), but subsequent research has shown that DRO is more likely to be effective if maintaining reinforcers are withheld follow-

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Reprints may be obtained from Brian Iwata, Psychology Department, The University of Florida, Gainesville, Florida 32611.

ing occurrences of the target behavior and are delivered following periods of nonresponding (Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993). When maintaining reinforcers are delivered in a DRO contingency, the procedure consists of both extinction (the maintaining reinforcer is withheld following problem behavior) and reinforcement (the reinforcer is delivered contingent on the absence of problem behavior).

Other variations in DRO contingencies are parametric in nature, such as the interval length (the minimal amount of time elapsed prior to the delivery of reinforcement) and whether the interval continues to its designated endpoint or resets to zero when a response occurs. The present study focuses on two parametric features of DRO: the omission contingency and the regularity of the schedule.

Most applications of DRO have been configured such that reinforcement is delivered only if responding is absent *throughout* the entire interval. This arrangement was described as “whole-interval DRO” by Repp, Barton, and Brulle (1983) to distinguish it from “momentary DRO,” in which the only requirement for reinforcement was the absence of responding *at the end* of the interval. Both terms were based on nomenclature used to differentiate whole-interval, partial-interval, and momentary time-sampling observation procedures. With respect to DRO, however, the distinction between whole- and partial-interval contingencies is unnecessary because any responding that occurs for less than an entire interval (partial-interval responding) results in either (a) nondelivery of reinforcement (under a whole-interval contingency) or (b) delivery of reinforcement as long as responding is absent at the end of the interval (under a momentary contingency). Thus, we will use the terms *interval* and *momentary* DRO to distinguish between these two variations in the omission contingency.

Very little research has been conducted on momentary DRO schedules. Harris and Wolchik (1979) compared the effects of momentary DRO, overcorrection, and time-out on the stereotypic behaviors of 4 male students who had been diagnosed with autism. When DRO was implemented during work periods, students were praised after every other academic trial if they were not engaged in stereotypy at that moment. When DRO was implemented during play periods, the students were praised and were given food if they were not engaging in stereotypy at the end of each 20-s interval. Overcorrection consisted of reprimanding the student and requiring him to engage in an exaggerated clapping exercise for 10 s contingent on stereotypy, and time-out consisted of reprimanding the student and turning away from him for 10 s. Overcorrection was the only procedure that suppressed all 4 students' stereotypy. Momentary DRO had little effect on 3 students' stereotypy and actually increased the 4th student's stereotypy.

Repp *et al.* (1983) conducted a comparative analysis of interval and momentary DRO in an attempt to decrease the disruptive behavior of 4 students who had been diagnosed with mild mental retardation. Two participants were exposed to momentary DRO followed by interval DRO. A 3rd participant was exposed to the reversed sequence, and, as an additional control for sequence effects, a 4th participant was exposed to baseline, interval DRO, and momentary DRO in a multielement design. Interval DRO was more effective than momentary DRO for the 2 students who were first exposed to momentary DRO. Results for the 3rd student showed that disruptions decreased considerably during interval DRO and remained low during the subsequent momentary DRO phase, and results for the 4th student showed that interval DRO was more effective than momentary DRO. Repp *et al.* concluded that interval DRO was more

effective than momentary DRO but suggested that momentary DRO might be useful as a maintenance procedure (following the use of interval DRO).

Derwas and Jones (1993) also compared interval and momentary DRO as treatments for stereotypy in 5 men who had been diagnosed with severe mental retardation. They reported that momentary DRO was more effective than interval DRO for 3 participants, that decreases in the 4th participant's stereotypy during interval DRO were maintained during a subsequent momentary DRO condition, and that momentary DRO increased the 5th participant's stereotypy.

With the exception of some of the results obtained by Derwas and Jones (1993), findings from the above studies suggest that interval DRO is a more effective intervention than momentary DRO. Although differences in results obtained with the two procedures might be attributed to a number of variables (e.g., type of reinforcer used, selection of interval length, resetting feature, etc.), these factors generally remained consistent across DRO procedures in the comparative studies. Another consistent feature of these studies, and one that might differentially influence the effectiveness of interval and momentary DRO, was the fact that the DRO interval remained constant. It is possible that the use of fixed-interval lengths produces regularity that can be discriminated. This is not a problem with interval DRO because, regardless of whether the end of the interval can be predicted, responding must be absent entirely in order for reinforcement to be delivered. By contrast, because the omission contingency in a momentary DRO procedure applies only to the end of the interval, it may be possible for an individual to receive reinforcement while still engaging in high rates of inappropriate behavior, as long as behavior ceases just before the interval ends.

One possible way to increase the effec-

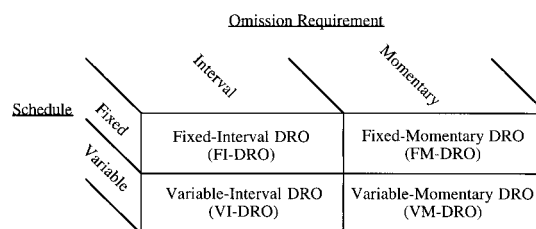


Figure 1. Diagram of the four DRO contingencies that can be created by altering the schedule (fixed vs. variable) and omission requirement (interval vs. momentary).

tiveness of momentary DRO contingencies would consist of varying the interval length within a session so that it cannot be easily discriminated. Figure 1 shows different configurations of DRO that result from alterations in the omission requirement (interval vs. momentary) and the interval length (fixed vs. variable). As noted previously, most DRO contingencies are based on fixed-interval schedules (FI DRO): Interval length remains constant, and reinforcement is delivered for the absence of responding throughout the interval. In variable-interval DRO (VI DRO), interval lengths vary throughout a session around an average value, and the omission requirement is the same as in FI DRO. The fixed-momentary DRO (FM DRO) schedule is one in which interval length remains constant, and reinforcement is delivered for the absence of responding at the end of the interval. Finally, variable-momentary DRO (VM DRO) is similar to FM DRO, except that the interval length varies throughout a session.

To our knowledge, only two studies have been conducted using variable DRO schedules. Topping and Crowe (1974) first trained college students to press a key according to either an FI or a VI schedule of reinforcement. Later, participants were shifted to FI DRO, VI DRO, or extinction. Results showed that, regardless of the reinforcement schedule used to establish the initial performance, both FI DRO and VI DRO proce-

dures suppressed key pressing more rapidly than did extinction (negligible differences were observed between the two DRO schedules).

In another study, Sisson, Van Hasselt, Hersen, and Aurand (1988) used VM DRO to decrease the disruptive and stereotypic behaviors of 3 children. The children received preferred foods if they were not engaging in the target behaviors when a music cue was presented according to a VI 20-s schedule. VM DRO failed to reduce the target behaviors of 2 of the children until the procedure was combined with either time-out or overcorrection. VM DRO reduced the 3rd participant's stereotypy, but overcorrection was added as a maintenance procedure. Although the results reported by Topping and Crowe (1974) suggested that variable DRO was effective, they used a VI DRO schedule, and it is not clear if similar results would be obtained with a VM DRO schedule. Sisson *et al.* reported limited effects with VM DRO, but it is unclear if the reinforcers that maintained disruption and stereotypy were withheld during treatment.

The purpose of this study was to examine the relative effects of VM DRO schedules as treatment for self-injurious behavior (SIB). By conducting a functional analysis prior to treatment, it was possible to configure all DRO schedules to insure that maintaining reinforcers were withheld and delivered. Comparative analyses were conducted in two phases. In the initial treatment phase, we compared FI DRO and VI DRO; in a later phase, we compared VI DRO and VM DRO.

## GENERAL METHOD

### *Participants and Setting*

Three adult women who lived in a state residential facility for persons with developmental disabilities participated. All were referred for assessment and treatment of SIB

and were selected for inclusion in this study based on results of their functional analyses, which indicated that their SIB was maintained by social-positive reinforcement (see below). Dot was a 28-year-old woman who had been diagnosed with profound mental retardation. Her SIB included head and body hitting, and biting. Dot was ambulatory, but she required assistance with most self-care tasks. She displayed minimal communication skills, which consisted of simple gestures. Jodi was a 43-year-old woman who had been diagnosed with profound mental retardation. Her SIB consisted of picking at her skin in areas where she had lacerations that previously had required stitches or in other areas with scars and wounds. Jodi was ambulatory and was able to perform basic self-care tasks independently. She had a limited verbal repertoire consisting of simple gestures and a few manual signs. Bridget was a 50-year-old woman who had been diagnosed with profound mental retardation. She had a long history of severe SIB that included head and body hitting and head banging. Bridget was ambulatory, and she was able to complete basic self-care tasks independently. She had a minimal verbal repertoire consisting of a few gestures.

All sessions were conducted at a day-treatment program located on the grounds of the facility where the participants lived. Sessions lasted 15 min and were conducted two to three times per day, 4 to 5 days per week, depending on the participants' daily schedules.

### *Response Measurement and Interobserver Agreement*

The primary dependent measure was number of responses per minute of SIB. Topographies of SIB included skin picking (Jodi), head and body hitting (Dot and Bridget), head banging (Bridget), and biting (Dot). *Skin picking* was defined as touching or rubbing areas of the skin containing scars

or open wounds with the fingers or open hand. *Head and body hitting* were defined as forceful (audible) contact of the hands or arms against the head or against any other portion of the body. *Head banging* was defined as forceful contact of the head against any hard surface, including furniture, the walls, or the floor.

Data were also taken on the therapist's delivery of consequences as a measure of treatment integrity. Delivery of attention was defined as a 3- to 5-s verbal interaction between the therapist and participant. The therapist also occasionally patted the participant's arm or back during the verbal interaction. Delivery of tangible reinforcement was defined as placing a leisure item on a table immediately in front of the participant. The therapist left the item on the table for 30 s during functional analysis sessions and for 20 s during baseline and DRO sessions.

Data were collected by trained observers on handheld computers (Assistant Model A102) during continuous 10-s intervals. Interobserver agreement was assessed by having a second observer simultaneously but independently collect data. Observers' records were then compared on an interval-by-interval basis. Agreement coefficients were calculated by dividing the smaller number of responses by the larger number of responses in each interval, averaging these values across the session, and multiplying by 100%. Interobserver agreement was assessed during 36.0% of the functional analysis sessions, 42.3% of the baseline sessions, and 31.7% of the treatment sessions. Across participants, mean agreement for SIB during functional analysis, baseline, and treatment sessions was 98.5% (range, 90.1% to 100%), 93.5% (range, 82.3% to 100%), and 97.9% (range, 93.0% to 100%), respectively. Mean agreement on the delivery of consequences during functional analysis, baseline, and treatment was 94.3% (range, 68.0% to

100%), with no consistent differences across conditions or schedules.

#### PHASE 1: FUNCTIONAL ANALYSIS

##### *Procedure*

Prior to the study, an assessment was conducted based on procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). Participants were exposed to a series of test and control conditions in a multielement design. The conditions were (a) Attention: The participant had access to leisure materials, and the therapist ignored the participant except to express concern each time the participant engaged in SIB. This condition was designed to determine if the participant's behavior was maintained by positive reinforcement in the form of attention. (b) Tangible (Dot only): Each time Dot engaged in SIB, the therapist allowed Dot to have access to a leisure item (Connect 4 game) for 30 s. This condition was included in Dot's functional analysis because her caregivers' reports suggested that her SIB was maintained by tangible reinforcement. (c) Demand: The therapist presented instructional trials on a fixed-time (FT) 30-s schedule using a three-prompt sequence (instruction, model, physical prompt). Compliance resulted in praise, and SIB produced termination of the trial until the next scheduled trial began. This condition was designed to determine if SIB was maintained by negative reinforcement in the form of escape from demands. (d) Alone: An observer was present in the room, but no social consequences were placed on SIB, and the participant did not have access to leisure materials. This condition was designed to determine whether SIB persisted in the absence of social consequences. (e) Play: The participant had access to leisure materials, and the therapist delivered attention to the participant on an FT 30-s schedule. This condition served as a control for the test conditions.

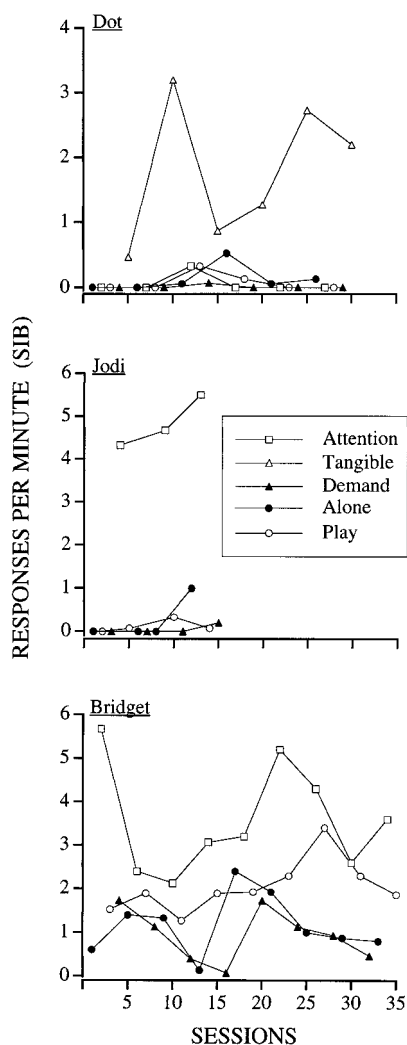


Figure 2. Responses per minute of SIB during functional analyses for Dot (top panel), Jodi (middle panel), and Bridget (bottom panel).

### Results

Figure 2 shows the results of each participant's functional analysis. Dot's behavior was maintained by access to tangible reinforcement. Her mean rate of SIB was 1.8 responses per minute in the tangible condition compared to mean rates of 0 to 0.1 responses per minute in other conditions. Jodi's functional analysis indicated that her SIB was maintained by attention. Her rate of SIB in the attention condition ( $M = 4.8$  responses per minute) was much higher than

in the other conditions (range of means, 0.1 to 0.3 responses per minute). Bridget's SIB also was maintained by attention. Her rate of SIB was higher in the attention condition ( $M = 3.6$  responses per minute) than in the other conditions (range of means, 0.9 to 2.0). The persistence of Bridget's SIB during play sessions may have been a carryover effect from the attention sessions that always preceded the play sessions. It may have been difficult for Bridget to discriminate between the two conditions because the same leisure items were available and the therapist delivered attention in both types of sessions.

### PHASE 2: ANALYSIS OF DRO SCHEDULES

#### Baseline

Procedures during baseline were identical to those of the functional analysis condition in which the participant engaged in the highest rate of SIB. Jodi's and Bridget's baselines consisted of the attention condition, whereas Dot's baseline consisted of the tangible condition. During baseline and DRO conditions in which a tangible item was delivered (Dot), reinforcer access time was subtracted from the total session time before calculating response rates. This procedure was followed to insure that rates of SIB would not be artificially suppressed merely as a function of engagement with the leisure item.

#### DRO Contingencies

Each participant was exposed to one or more variations of a DRO contingency, which shared the following characteristics. The basic contingency involved termination of reinforcement for SIB (extinction), combined with delivery of a reinforcer for the absence of SIB according to rules described below under each schedule. When a participant met criterion, the therapist delivered the designated reinforcer; otherwise, SIB was ignored, the interval ended as scheduled (i.e., DRO intervals were not reset imme-

diately following the occurrence of SIB), and a new interval began. The reinforcers used during DRO conditions were the same as those used during baseline conditions. Jodi and Bridget received attention for 3 to 5 s; Dot received access to the Connect 4 game for 20 s. DRO schedules were based on mean IRTs of SIB during preceding sessions. The mean IRT of each session was calculated by dividing the total session time by the number of responses that occurred during the session. The initial DRO value was equal to the mean IRT (rounded to the nearest second) of all of the baseline sessions, and subsequent values were derived from the mean IRT during the previous three sessions. For example, after the first DRO session, the therapist used the mean IRT from the last two baseline sessions and the first DRO session to determine the DRO interval for the next session (with the exception that DRO intervals did not increase by more than 100% from one session to the next). Thus, although all DRO schedules were equivalent initially, the interval length of each DRO condition for a given session changed as a function of rates of SIB that occurred during previous sessions of that condition.

*Fixed-interval DRO.* Interval length was determined as noted previously and remained constant throughout a session. If the participant refrained from engaging in SIB for the entire interval, the therapist delivered reinforcement when the interval ended. However, if the participant engaged in SIB at any time during the interval, reinforcement was not delivered.

*Variable-interval DRO.* The only difference between the FI and VI schedules was that, under the VI schedule, interval length did not remain constant during a session. Instead, interval length varied around its predetermined mean value. Under the VI schedule, DRO intervals were 50%, 75%, 100%, 125%, and 150% of the mean inter-

val length, and the interval sequence was determined in a quasirandom fashion (random ordering with equal representation).

*Variable-momentary DRO.* This schedule differed from the VI schedule on one important dimension: During VM DRO sessions, the participant was not required to refrain from engaging in SIB during the entire interval in order to receive reinforcement. Instead, reinforcement was delivered if the participant was not engaging in SIB at the moment the interval ended.

### *Experimental Designs*

Our primary interest was the examination of VM DRO schedules. However, as a variant of the more traditional FI schedule, the VM schedule involved two changes: a parametric change in interval length (fixed vs. variable) and a change in the omission requirement for reinforcement (interval vs. momentary). If a direct comparison of these two schedules demonstrated that VM DRO was less effective than an FI DRO schedule, it would be difficult to attribute differences to a specific source of procedural variation. Therefore, Dot and Jodi participated in a two-stage comparative analysis. Transitions from baseline to treatment conditions were sequenced in a multiple baseline across subjects design, and within-subject comparisons of DRO schedules were arranged in multi-element designs. Two therapists conducted baseline and treatment sessions for each participant to enhance discriminability between conditions. During the first comparison, one therapist conducted FI DRO sessions; the other therapist conducted VI DRO sessions. The purpose of this initial comparison was to determine if varying the interval length altered the effectiveness of an interval DRO schedule. After returning to baseline conditions, a second comparison was then made between VI DRO and VM DRO. The purpose of this comparison was to determine if

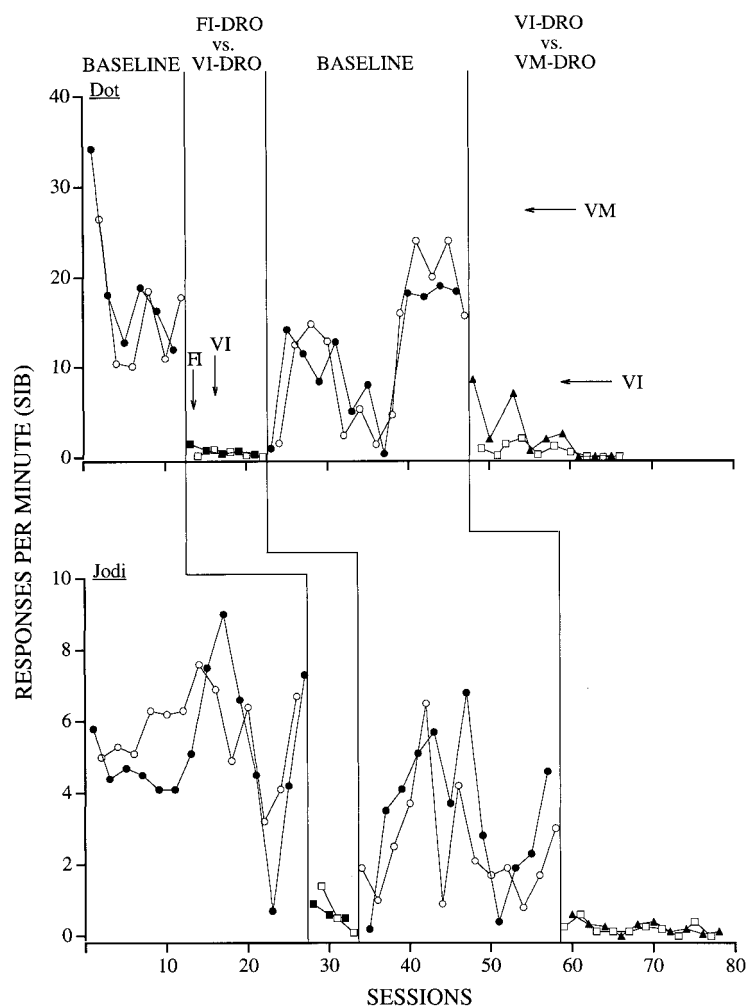


Figure 3. Responses per minute of SIB during baseline and treatment conditions for Dot (top panel) and Jodi (bottom panel).

a momentary DRO contingency would be as effective as an interval contingency.

Although the multielement design is often used in comparative analyses, results obtained during concurrent implementation of more than one condition may be prone to multiple treatment interference (Higgins Hains & Baer, 1989). Because both components of the comparison conditions for Dot and Jodi involved similar contingencies, it is possible that behavior in one condition may have been affected by procedures implemented during the other condition. Therefore, to evaluate the effects of the VM

DRO schedule in the absence of other interventions, Bridget was exposed only to the VM DRO procedure in a reversal design.

### Results

Figure 3 shows results of the two-stage analysis of DRO schedules for Dot and Jodi. Dot's rate of SIB during the first baseline condition was moderately high and relatively stable during the final sessions. During the first comparison (FI DRO and VI DRO), the initial interval length for both schedules was 4 s. Dot's SIB quickly dropped to below 1 response per minute in both conditions. A

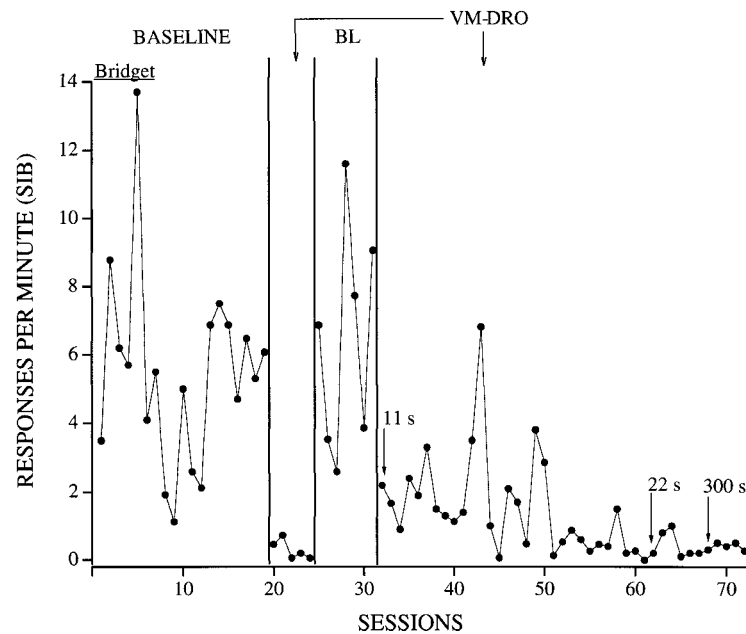


Figure 4. Responses per minute of SIB during baseline and treatment conditions for Bridget.

return to baseline was associated with an increase in SIB to levels comparable with those observed during the original baseline. During the second DRO comparison (VI DRO and VM DRO), the initial interval length for both schedules was again 4 s. Dot's SIB again decreased under both schedules (although rates were initially higher under VM DRO), such that both DRO schedules had been thinned to beyond 500 s by the ninth treatment session of each condition. The final interval lengths of the VI DRO and the VM DRO schedules were 594 s and 533 s, respectively.

Jodi's rate of SIB during the initial baseline was somewhat variable. Initial interval length during the first DRO comparison was 18 s. Jodi's rate of SIB quickly decreased to almost zero during both the FI DRO and VI DRO conditions within three sessions. Variable rates of SIB were again observed during the return to baseline. During the second DRO comparison, the initial interval length was 21 s. Jodi's SIB quickly decreased to near-zero levels under both the VI DRO

and VM DRO conditions. We set a maximum target interval length of 300 s for Jodi because this schedule seemed practical yet still insured frequent delivery of reinforcement. Jodi reached this target interval by the fifth treatment session of both DRO conditions. Her SIB remained low (below 0.5 responses per minute) for an additional five sessions under both DRO conditions at the 300-s interval length.

Figure 4 shows results obtained for Bridget, who was exposed only to the VM DRO procedure. During baseline, her rates of SIB were variable. During the first VM DRO condition, the initial interval length was 15 s. Bridget's SIB during this condition decreased immediately almost to zero. Her SIB increased again during the second baseline. The initial interval length during the second VM DRO condition was 11 s. Reduction of SIB did not occur as quickly during this second treatment condition; therefore, DRO intervals were not lengthened until several sessions had elapsed during which SIB occurred at low rates. Bridget's SIB continued

Table 1  
Percentage of Reinforcers Earned Under Different DRO Schedules

Participant	FI DRO		VI DRO		VM DRO	
	Mean	Range	Mean	Range	Mean	Range
Dot	37.0	17.3–52.2	34.7	0–100	57.6	17–100
Jodi	65.1	56.3–71.0	54.8	25–100	87.1	66.7–100
Bridget					90.9	61.7–100

to decrease throughout this condition, her DRO interval was doubled on Session 61, and she reached the terminal DRO interval (300 s) by Session 68. Her SIB remained below 0.5 responses per minute under this schedule for four additional sessions.

Data collected on the delivery of reinforcers are summarized in Table 1 as the mean percentage of reinforcers earned under the different DRO schedules. Dot and Jodi both were exposed to all three of the schedules, and their data indicate that the largest proportion of reinforcers was earned under the VM DRO schedule. That is, VM DRO resulted in the highest rates of reinforcement. Bridget, who was exposed only to VM DRO, earned over 90% of the scheduled reinforcers.

## DISCUSSION

Results of this study demonstrated that two variations of DRO schedules, variable-interval and variable-momentary, were as effective as the more traditional fixed-interval schedule in decreasing SIB maintained by social-positive reinforcement. The effects observed with the VM DRO schedule were consistent across 3 participants and are particularly noteworthy in light of previous findings that momentary DRO schedules were not very effective (Harris & Wolchik, 1979; Repp *et al.*, 1983; Sisson *et al.*, 1988).

A number of factors may have accounted for discrepancies between our results and those reported in previous research on momentary DRO. First, it is unclear if the re-

inforcer that maintained the target behaviors in previous studies was identified prior to treatment and was withheld and delivered during treatment. If not, the effectiveness of momentary DRO may have been limited in two ways. First, it is possible that the DRO contingency did not include extinction. Although there are no programmed consequences for the target behavior in typical DRO procedures, delivery of an arbitrary reinforcer (one that does not maintain the target behavior) does not insure that the functional (maintaining) reinforcer is withheld (Mazaleski *et al.*, 1993). For example, if some form of material reinforcement (e.g., food) were delivered in a DRO procedure for problem behavior maintained by attention, yet therapists continued to reprimand or redirect the individual to another activity following occurrences of problem behavior, the absence of behavior would produce the programmed reinforcer, but occurrences of problem behavior would be reinforced as well. Second, it is possible that the stimulus delivered during DRO was neither an arbitrary nor a maintaining reinforcer. In the present study, results of a functional analysis (a) indicated that all 3 participants' SIB was maintained by social-positive reinforcement and (b) identified specific stimuli associated with high rates of SIB (attention for Jodi and Bridget; access to materials for Dot). Thus, all of the DRO contingencies used in the present study incorporated both extinction and reinforcement components in which functional (maintaining) reinforcers were withheld and delivered.

A second difference that may account for our findings is that, with the exception of the Sisson et al. (1988) study, research on momentary DRO has been limited to the use of fixed-momentary schedules. The VM DRO schedule used in the present study may have been more effective than the FM DRO schedules used previously because the point in time at which nonoccurrence of the target behavior is critical (the end of the interval) cannot be discriminated easily under a VM DRO schedule. By contrast, the regularity of the FM DRO schedule, combined with the requirement that responding be absent only at the end of the interval, may allow an individual to engage in high rates of problem behavior throughout the interval yet receive reinforcement by stopping near the end of the interval. Because FM DRO schedules might be considered the least likely of all DRO variations to suppress behavior, we did not include them in the present analysis; for this reason, our account is somewhat speculative.

A third difference between the current study and previous research was the method used for determining DRO interval lengths. We set the DRO intervals according to participants' rates of SIB during baseline sessions. As a result, very rich DRO schedules (e.g., 4 s for Dot) were used initially. We also used the participants' rates of responding to determine how DRO schedules were thinned. By contrast, the momentary DRO schedules used in previous research (with the exception of Derwas & Jones, 1993) were determined arbitrarily. Different results may have been obtained in the previous studies if different, perhaps richer, schedules had been used.

Given that all three DRO schedules were shown to be effective in reducing SIB to near-zero rates, the VM DRO schedule has several potential advantages over the more traditional FI DRO schedule. First, VM DRO schedules are more practical than are

FI DRO schedules because the therapist is not required to monitor the participant's behavior at all times (i.e., throughout the DRO interval). Instead, the therapist merely needs to observe the participant at the moment the interval ends to determine whether reinforcement should be delivered. This feature of VM DRO may make it more feasible than FI DRO when therapists, teachers, or parents engage in activities with more than one individual at a time, or when their attention is temporarily diverted from the participant, as is common in many situations at home or at school.

The second advantage of VM DRO schedules is that, because the criterion for reinforcement is less stringent than it is with FI DRO or VI DRO schedules, the participant is likely to experience a higher rate of reinforcement under the VM DRO schedule. One limitation of interval DRO schedules is that, depending on the interval length and the rate of the target behavior, it is possible that the participant will receive a small proportion of scheduled reinforcers, such that the DRO procedure functions primarily as extinction (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). Data from the present study indicated that Dot occasionally received no reinforcers during VI DRO sessions, and that the highest rates of reinforcement for both Dot and Jodi occurred under the VM DRO schedule. Rate of reinforcement may be important because sustained deprivation from reinforcement, as might be experienced under an interval DRO contingency, may function as an establishing operation, thereby occasioning the very behavior that the procedure has been designed to reduce.

Although the primary purpose of this study was the examination of VM DRO schedules, the initial treatment conditions for Dot and Jodi included a comparison of FI DRO and VI DRO. Given the similar results obtained with these two procedures,

it is unclear whether one schedule has any notable advantage over the other. For example, the limitation noted previously with FM DRO schedules (their predictability) does not apply to FI DRO schedules. Even though FI DRO schedules may be just as predictable as FM DRO schedules, the interval feature of the FI DRO schedule requires the complete absence of the target behavior as a criterion for reinforcement. Moreover, rates of reinforcement under the two interval schedules were comparable. Perhaps one practical advantage of the FI DRO schedule over the VI DRO schedule is that the therapist does not have to monitor schedule changes because interval length in the FI DRO schedule remains constant.

One limitation of the present study is that we included only individuals whose behavior problems were maintained by social-positive reinforcement. Momentary DRO schedules have not been evaluated as treatment for behavior maintained by negative reinforcement (escape). However, Vollmer, Marcus, and Ringdahl (1995) recently described the use of an FI DRO schedule (differential negative reinforcement of other behavior) with 1 individual, in which the absence of problem behavior during instructional trials produced periodic escape, and it is possible that VM DRO schedules might be similarly effective. Also, we specifically excluded from participation individuals whose behavior problems were maintained by automatic reinforcement to insure that all DRO schedules were derived from functional reinforcers. Had we used arbitrary reinforcers with such behavior and obtained failure with one or more of the DRO schedules, it would have been unclear whether the failure was a characteristic of the particular schedule or was merely due to the fact that the arbitrary reinforcer delivered in the DRO procedure was not powerful enough to compete with the automatic reinforcer produced by the target behavior. Although arbitrary DRO contingencies may

have limited effects with behavior problems maintained by automatic reinforcement, VM DRO schedules such as those used in the present study might be at least as effective as traditional FI DRO schedules.

A second limitation of the study is that only 1 participant was treated with a VM DRO schedule without prior or concurrent exposure to other DRO schedules. Bridget's data provide rather clear evidence that VM DRO is an effective treatment even when it is implemented as the sole intervention. However, given the Repp *et al.* (1983) findings that FM DRO was effective only as a maintenance procedure (following FI DRO), it is possible that the reductions in Dot's and Jodi's SIB observed during the VM DRO condition were due to previous or concurrent exposure to interval DRO schedules (FI DRO and VI DRO).

A third limitation is that we examined the effects of DRO as a sole intervention; this was necessary to isolate the effects of each schedule. Thus, participants were not explicitly taught to engage in alternative responses that produced access to reinforcement. This limitation applies equally to all DRO contingencies and is not unique to a particular schedule variation. However, in clinical application, DRO procedures should be combined with (or followed by) differential reinforcement contingencies that establish and maintain more socially appropriate forms of alternative behavior.

In conclusion, this study demonstrated that momentary DRO contingencies, which have been found to be relatively ineffective in previous research when implemented as FM DRO schedules, can be highly effective when implemented as VM DRO schedules. These findings provide an alternative to the more traditional FI DRO schedule in situations in which DRO is used as a treatment for behavior problems maintained by positive reinforcement.

## REFERENCES

- Derwas, H., & Jones, R. S. (1993). Reducing stereotyped behavior using momentary DRO: An experimental analysis. *Behavioral Residential Treatment*, 8, 45–53.
- Harris, S. L., & Wolchik, S. A. (1979). Suppression of self-stimulation: Three alternative strategies. *Journal of Applied Behavior Analysis*, 12, 185–198.
- Higgins Hains, A., & Baer, D. M. (1989). Interaction effects in multielement designs: Inevitable, desirable, and ignorable. *Journal of Applied Behavior Analysis*, 22, 57–69.
- Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis*, 27, 197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities*, 2, 3–20, 1982)
- Lennox, D. B., Miltenberger, R. G., Spengler, P., & Erfanian, N. (1988). Decelerative treatment practices with persons who have mental retardation: A review of five years of the literature. *American Journal on Mental Retardation*, 92, 492–501.
- Mazaleski, J. L., Iwata, B. A., Vollmer, T. R., Zarcone, J. R., & Smith, R. G. (1993). Analysis of the reinforcement and extinction components in DRO contingencies with self-injury. *Journal of Applied Behavior Analysis*, 26, 143–156.
- Poling, A., & Ryan, C. (1982). Differential reinforcement of other behavior schedules: Therapeutic applications. *Behavior Modification*, 6, 3–21.
- Repp, A. C., Barton, L. E., & Brulle, A. R. (1983). A comparison of two procedures for programming the differential reinforcement of other behaviors. *Journal of Applied Behavior Analysis*, 16, 435–445.
- Reynolds, G. S. (1961). Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 4, 57–71.
- Sisson, L. A., Van Hasselt, V. B., Hersen, M., & Auran, J. C. (1988). Tripartite behavioral intervention to reduce stereotypic and disruptive behaviors in young multi-handicapped children. *Behavior Therapy*, 19, 503–526.
- Topping, J. S., & Crowe, J. T. (1974). Comparison of three response elimination procedures following FI and VI reinforcement training in humans. *Bulletin of the Psychonomic Society*, 3, 49–51.
- Uhl, C. N., & Garcia, E. E. (1969). Comparison of omission with extinction in response elimination in rats. *Journal of Comparative and Physiological Psychology*, 69, 554–562.
- Vollmer, T. R., & Iwata, B. A. (1992). Differential reinforcement as treatment for behavioral disorders: Procedural and functional variations. *Research in Developmental Disabilities*, 13, 393–417.
- Vollmer, T. R., Iwata, B. A., Zarcone, J. R., Smith, R. G., & Mazaleski, J. L. (1993). The role of attention in the treatment of attention-maintained self-injurious behavior: Noncontingent reinforcement and differential reinforcement of other behavior. *Journal of Applied Behavior Analysis*, 26, 9–21.
- Vollmer, T. R., Marcus, B. A., & Ringdahl, J. E. (1995). Noncontingent escape as treatment for self-injurious behavior maintained by negative reinforcement. *Journal of Applied Behavior Analysis*, 28, 15–26.

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## STUDY QUESTIONS

1. What is a differential-reinforcement-of-other-behavior (DRO) contingency, and what are some of the ways in which this contingency can be varied?
2. Describe the four variations in DRO resulting from alterations in the omission requirement and interval schedule.
3. Why was reinforcer access time subtracted from the total session time before calculating response rates during treatment conditions only for Dot?
4. Given the authors' primary interest in VM DRO schedules, what was the rationale for their two-stage evaluation strategy?
5. Briefly summarize the results obtained with respect to the relative effectiveness of the different DRO schedules.

6. What explanation did the authors provide for excluding FM DRO from the present analysis, and why would an evaluation of its effects have been helpful?
7. According to the authors, what are the potential advantages of VM DRO over FI DRO, and what data were offered by way of support?
8. Although not discussed by the authors, what are some potential disadvantages of the VM DRO schedule?

Questions prepared by Juliet Conners and Eileen Roscoe, The University of Florida